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(74) Agents: CRISS, Roger, H. et al.; Honeywell International Inc., 101 Columbia Road, P.O. Box 2245, Morristown, NJ 07960 (US).

(81) Designated State *(national)*: JP.

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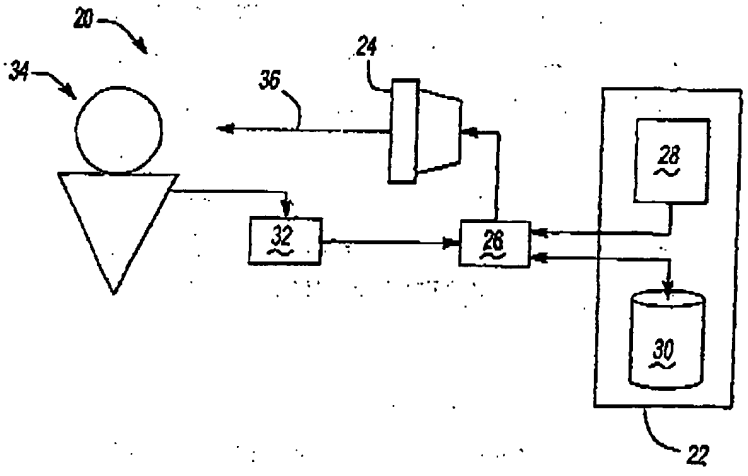
(54) Title: METHODS AND APPARATUS FOR DISPLAYING MUTIPLE DATA CATEGORIES



(57) Abstract: Methods and apparatus are provided for displaying multiple data categories. The apparatus is comprised of a display that is configured to produce visual representations of the plurality of data categories and a processor that is configured to control the display such that at least one of three display modes is provided for the visual representations of the plurality of data categories. The first display mode provided by the apparatus and method is a transparency mode for at least one of the visual representations of one of the data categories and the second display mode provided by the apparatus and method is a dynamic layering mode for the visual representations of the plurality of data categories. The third display mode is a color prioritization mode for at least three of the visual representations of three of the data categories. One or more of these display modes prevents visual representations of the plurality of data categories with the display in a manner that assists cognitive mapping between the display and the user and/or operator of the

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METHODS AND APPARATUS FOR DISPLAYING MUTIPLE DATA CATEGORIES

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to displaying multiple data categories, and more particularly to methods and apparatus for displaying multiple data categories.

[0002] A display provides a visual presentation of information. This visual presentation of information with a display can include multiple data categories. For example, multiple data categories corresponding to sensors and systems of a vehicle can be visually presented to a vehicle operator with a display. The multiple data categories can be any number of classes or divisions in a classification scheme of information that are to be visually represented on a display such as navigation data (e.g., navigation aid or NAVAID data, airport data, fix data, lateral/vertical/time flight plan route data, communication frequency data, latitude and longitude data, Grid Minimum Off-Route Altitude (Grid MORA) data, air traffic control and boundary data, magnetic variation data, time zone data, approach and departure chart data, airport diagram data, city data, road data, railroad data, elevation contour line data, river data, lake data, uplink weather data, winds aloft data, airspace data, airway data and absolute terrain data, or the like) and sensor data (e.g., airborne weather data, Automatic Dependent Surveillance – Broadcast (ADS-B) data, obstacle data, traffic sensor data or Traffic alert and Collision Avoidance System (TCAS), relative terrain data and Enhanced Ground Proximity Warning System (EGPWS) data) of an aircraft.

[0003] Displays have continued to advance in sophistication and have achieved increasingly higher levels of information density that enable the visual presentation of a greater number of data categories, which is also referred to as data fusion. These advancements provide the visual display of multiple data categories that can be readily assimilated by an operator and/or user of the display and can also

provide a reduction in unnecessary information to ease the task of perceiving and understanding a data category of interest. However, as the information density continues to increase, methods and apparatus are desirable that visually display the data categories in a manner that provides proper cognitive mapping between the operator and/or user of a display and also reduces the effort of the operator and/or user in assimilating one or more of the data categories of interest.

[0004] In view of the foregoing, it should be appreciated that it would be desirable to provide an apparatus for displaying multiple data categories. In addition, it should be appreciated that it would be desirable to provide a method for displaying multiple data categories. Furthermore, additional desirable features will become apparent to one skilled in the art from the drawings, foregoing background of the invention, following detailed description of a preferred exemplary embodiment and appended claims.

BRIEF SUMMARY OF THE INVENTION

[0005] An apparatus and method are provided for displaying a plurality of data categories. The apparatus is comprised of a display that is configured to produce visual representations of the plurality of data categories and a processor that is configured to control the display such that at least one of three display modes is provided for the visual representations of the plurality of data categories. The first display mode provided by the apparatus and method is a transparency mode for at least one of the visual representations of one of the data categories. The second display mode provided by the present apparatus and method is a dynamic layering mode for the visual representations of the plurality of data categories. The third display mode is a color prioritization mode for at least three of the visual representations of three of the data categories. One or more of these display modes presents visual representations of the plurality of data categories with the display in a manner that assists cognitive mapping between the display and the user and/or

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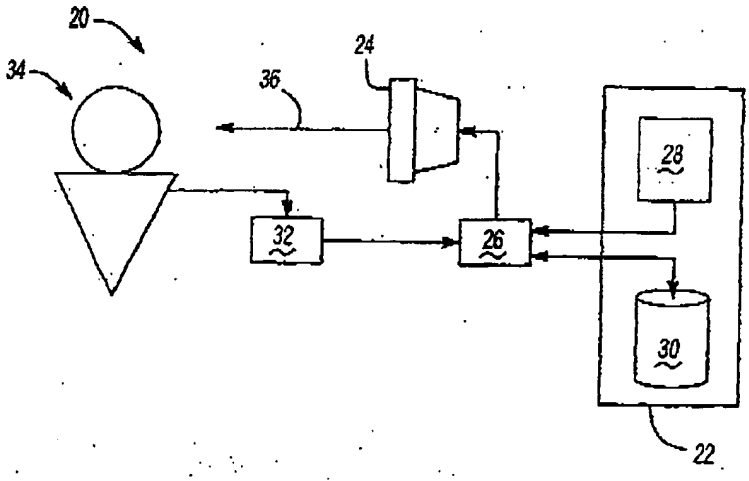

(57) Abstract: Methods and apparatus are provided for displaying multiple data categories. The apparatus is comprised of a display that is configured to produce visual representations of the plurality of data categories and a processor that is configured to control the display such that at least one of three display modes is provided for the visual representations of the plurality of data categories. The first display mode provided by the apparatus and method is a transparency mode for at least one of the visual representations of one of the data categories and the second display mode provided by the apparatus and method is a dynamic layering mode for the visual

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[0013] FIG. 7 is the Commission International de l'Eclairage (CIE) Uniform Chromaticity-Scale (UCS) of nineteen hundred and seventy-six (1976).

DETAILED DESCRIPTION OF A PREFERRED EXEMPLARY EMBODIMENT

[0014] The following detailed description of a preferred embodiment is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention.

[0015] Referring to FIG. 1, an apparatus 20 is illustrated for displaying data categories 22 according to a preferred exemplary embodiment of the present invention. The apparatus 20 is comprised of a display 24 that is configured to produce visual representations of the data categories 22. The display 24 can be any current and future display that is suitable for producing visual representations of the data categories 22 and preferably a multi-color display. For example, the display 22 can be a color Cathode Ray Tube display (CRT), monochrome CRT display, Liquid Crystal Display (LCD), plasma display, Flat-Panel Display (FPD), electro-luminescent display, vacuum fluorescent display, Heads-Up Display (HUD), Heads-Down Display (HDD), Helmet Mounted Display (HMD), Light Emitting Diode (LED) display or the like.

[0016] In addition to the display 24, the apparatus 20 of the present invention is also comprised of a processor 26 in operable communication with the display 22 to control the display 24 during production of the visual representations of the data categories 22. The processor 26 preferably encompasses one or more functional blocks and can include any number of individual microprocessors, memories, storage devices, interface cards, and other processor components. The processor 26 is configured to receive and/or access the data categories 22 and also communicate with an input device 32, which can be any device suitable for accepting input from a user 34, such as a cursor control device (e.g., touch-pad, joystick, mouse,

[0018] The processor 26 is configured to control the display 24 such that at least one of three display modes is provided for the visual representations of the data categories 22. The first display mode is preferably a transparency mode for at least one visual representation of one of the data categories 22, the second display mode is preferably a dynamic layering mode for at least two of the visual representations of two of the data categories 22, and the third display mode is preferably a color prioritization mode for at least three of the visual representations of three of the data categories 22. One or more of these display modes presents visual representations of the data categories to the user 34 in a manner that preferably assists with the cognitive mapping between the display 24 and the user 34 and/or reduces the time, error and/or effort of the user 34 in assimilating at least one data category of interest.

[0019] Referring to FIG. 2, the display 24 is shown in the first display mode (i.e., transparency mode) according to a preferred exemplary embodiment of the present invention. In order to maintain simplicity and clarity in this detailed description of a preferred exemplary embodiment, the display 24 is illustrated with visual representations of four data categories (i.e., data fusion of four data categories). More specifically, visual representations of weather sensor data 38, airway data 40, airspace data 42 and compass heading data 44 is produced by the display 24 under the control of the processor 26 as shown in FIG. 1. However, any number of visual representations of aircraft data categories can be produced on the display and other data categories in other vehicle and non-vehicle applications can be produced on the display 24 as previously discussed in this detailed description of a preferred exemplary embodiment (e.g., data categories of other land, water, air or space vehicles and non-vehicle applications such as simulators, Computer Aided Design (CAD) systems, video games, control systems of stationary objects, medical diagnostic devices, weather forecasting systems and laptop and desktop computers that utilize a display for visual presentation of data categories).

40 and preferably the other visual representations of data categories in common regions of the display. The processor 26 as shown in FIG. 1 is also configured to control the display 24 of FIG. 1 for production of additional transparency levels that provide additional levels of transparency of the visual representation for the weather sensor data 38 and additional levels of visibility for the airway data 40 and preferably the other categories (e.g., airspace data 42 and compass heading data 44) in common regions of the display. For example, a second enlarged view 58 of the region 54 of Fig 2 is shown with the visual representation of the weather sensor data 38 produced at a second transparency level 60 that provides a second level of transparency of the visual representation for the weather sensor data 38, which is about less than the first transparency level 56 and a second level of visibility of the visual representation for the airway data 40 that is about less than the first level of visibility. Furthermore, as shown in the third enlarged view 62 of the region 54 of Fig. 2, the visual representation for the weather sensor data 38 is produced at a third transparency level 64 that provides a third level of transparency of the visual representation of weather sensor data 38 that is about less than the second transparency level 60 and a third level of visibility of the visual representation for airway data 40, which is about less than the second level of visibility. In addition, any number of other transparency levels can be produced with degrees of transparency and visibility greater than and/or less than the first transparency level 56, second transparency level 60 and third transparency level 64.

[0023] Referring to FIG. 1, the first transparency level 56, second transparency level 60 and third transparency level 64 illustrated in FIG. 3, or some other transparency level, is preferably selected by the user 34. For example, the user 34 can select one of the transparency levels (56,60,64) illustrated in FIG. 3 using any number of input devices in operable communication with the processor 26, such as a virtual control formed of the cursor control device 32 and a graphical user interface (GUI) (not shown) generated on the display24, for example. Alternatively, one of the transparency levels (56,60,64) illustrated in FIG. 2, or some other transparency level, can be selected based upon other non-user inputs of the apparatus 20. For example, the transparency levels (56,60,64) illustrated in FIG. 2, or some other transparency

representations of the airway data 40, airspace data 42 and compass heading data 44 (i.e., the visual representation of weather sensor data 38 masks the visual representations of the airway data 40, airspace data 42 and compass heading data 44 in common regions of the display). The processor 26 as shown in FIG. 1 is also configured to provide an altered mode of the display 24 that alters the visual representations of the data categories (38,40,42,44) such that at least one or more of the visual representations of airway data 40, airspace data 42 and compass heading data 44 is superimposed over the weather sensor data 38 as shown in FIG. 5 (i.e., the visual representation of at least one or more of the visual representations of airway data 40, airspace data 42 and compass heading data 44 masks the visual representation of the weather sensor data 38 in common regions of the display). The processor 26 as shown in FIG. 1 is configured to provide the default mode and altered mode based upon predefined events.

[0026] More specifically and with continuing reference to FIG. 4, the visual representation of weather sensor data 38 is preferably superimposed over the visual representation of the airway data 40, airspace data 42 and compass heading data 44 in the default mode of the dynamic layering mode. In this illustrative example, which should not be construed as a limiting embodiment of the invention, the visual representation of weather sensor data 38 is superimposed with a first color (e.g., red color) 66 for high intensity weather, a second color (e.g., yellow color) 68 for intermediate intensity weather and a third color (e.g., green color) 70 for low intensity weather. The first color 66, second color 68 and third color 70 providing the visual representation of weather sensor data 38 substantially reduces or eliminates the visibility of the one or more of the other data categories (40,42,44) in common or intersecting regions of the display 24 more than one of the other visual representations of data categories (40,42,44). As can be appreciated from this description of a preferred exemplary embodiment of the present invention, this default mode of the dynamic layering mode assists the cognitive mapping between the display 24 and the user and/or reduces the time, error and/or effort of the user in assimilating a data category of interest (e.g., the visual representation of weather sensor data 38 as the data category of interest). However, the data category of interest to the user 34 can

altered mode of the second display mode as illustrated in FIG. 5. Alternatively, the processor 26 can be configured to control the display 24 in order to provide the default mode of the second display mode as illustrated in FIG. 4 until the processor identifies a non-user input. For example, the processor 26 can be configured to control the display 24 in order to provide the default mode of the second display mode as illustrated in FIG. 4 until the processor identifies a predefined event in the sensor data 28 (e.g., relative terrain data indicates that the distance between the aircraft and the terrain is less than a predefined distance) at which time the processor 26 controls the display 24 to provide the default mode of the second display mode as illustrated in FIG. 5. Therefore, the default mode and altered mode or altered modes of the dynamic layering mode can be selected by the user 34 or the apparatus 20 to provide a visual representation of one or more of the data categories 22 that assists the cognitive mapping between the display 24 and the user 34 and/or reduces the time, error and/or effort of the user 34 in assimilating at least of the data categories 22 of interest. As previously alluded in the brief summary of the invention and this detailed description of a preferred exemplary embodiment, the dynamic layering mode can assist in the cognitive mapping and data assimilation without additional display modes or with additional display modes, such as the transparency mode and/or the color prioritization mode.

[0029] Referring to FIG. 6, the display 24 is illustrated in the color prioritization mode (i.e., third display mode) according to a preferred exemplary embodiment of the present invention. In order to maintain the simplicity and clarity in this detailed description of a preferred exemplary embodiment, the display 24 is illustrated with the visual representation of three data categories (i.e., data fusion of three data categories). More specifically, the visual representation of airway data 40, airspace data 42 and compass heading data 44 is produced by the display 24 under the control of the processor 26 as shown in FIG. 1. However, as previously discussed with reference to the first display mode and the second display mode, any number of visual representations of aircraft data categories can be produced on the display 24 and data categories in other vehicle and non-vehicle applications can be produced on the display 24 in accordance with the present invention (e.g., data categories of other

diagram (1976) 76 is shown that presents color space of a first color (e.g., red 66), second color (e.g., green) 70 and third color (e.g., blue) 74 in terms of luminance (Y), a first chromaticity coordinate (u') 80 and a second chromaticity coordinate (v') 82, where chromaticity (u',v') is the measure of hue and saturation, hue is related to the wavelength of the color and is represented by the coordinates on the CIE UCS diagram 76, saturation is represented by the relative distance from the center or equal energy point 78 and luminance (Y) is the achromatic aspect of a color stimulus. The three quantities of CIE UCS color space (i.e., Y, u', v') are used to define chromatic and achromatic aspects of a color stimulus and provide a replicable description of colors.

[0032] The three quantities of CIE UCS color space (i.e., Y, u', v') are utilized in accordance with the present invention to select the first color and the second color. The first color and the second color for the respective data category are selected based upon the symbol and background contrast recommendations of the International Organization for Standardization with the following equation:

$$\Delta E\,(Y,u',v') = [(155\,\Delta Y/Y_{max})^2 + (367\,\Delta u')^2 + (167\,\Delta v')^2]^{1/2} \qquad (1)$$

Where the differential values (i.e., ΔY, $\Delta u'$ and $\Delta v'$) relate the differences between the chromaticity (u',v') and luminance (Y) of two colors and Y_{max} is the maximum luminance of the display. However, the first color and second color for the respective data category can be selected based upon other considerations or recommendations.

[0033] The first color for the first data category having the first priority can be selected with equation (1) such that the color difference (ΔE) between the first color and the background color is preferably greater than about seventy-five (75), more preferably greater than about ninety (90) and most preferably greater than about one hundred (100), while the second color for the second data category having the second priority can be selected with equation (1) such that the color difference (ΔE) between the second color and the background color is preferably less than about

CLAIMS

What is claimed is:

1. An apparatus for displaying a plurality of data categories, comprising:

a display that is configured to produce a first visual representation of a first data category of the plurality of data categories and a second visual representation of said second data category of the plurality of data categories; and

a processor that is configured to control said display during production of said first visual representation of said first data category and said second visual representation of said second data category such that said first visual representation of said first data category is at least partially transparent to provide at least partial visibility of said second visual representation of said second category through said first visual representation of said first data category.

2. The apparatus of Claim 1, wherein said display is configured to produce a third visual representation of a third data category of the plurality of data categories and said processor is configured to control said display during production of said first visual representation of said first data category and said third visual representation of said third data category such that said first visual representation of said first data category is at least partially transparent to provide at least partial visibility of said third visual representation of said third category of data through said first visual representation of said first data category.

3. The apparatus of Claim 2, wherein said display is configured to produce a fourth visual representation of a fourth data category of the plurality of data categories and said processor is configured to control said display during production of said first visual representation of said first data category and said fourth visual representation of said fourth data category such that said first visual representation of said first data category is at least partially transparent to provide at least partial visibility of said fourth visual representation of said fourth data category through said first visual representation of said first data category.

10. An apparatus for displaying a plurality of data categories, comprising:

a display that is configured to produce a first visual layer representation of a first data category of the plurality of data categories and a second visual layer representation of a second data category of said plurality of data categories;

a processor that is configured to control said display to present said first visual representation of said first data category superimposed over said second visual representation of said second data category and superimpose said second visual representation of said second data category over said first visual representation of said first data category if a predefined event is identified by said processor.

11. The apparatus of Claim 10, wherein said display is configured to produce a third visual representation of a third data category of the plurality of data categories and said processor is configured to control said display to present said first visual representation of said first data category superimposed over said third visual representation of said third data category and superimpose said third visual representation of said third data category over said first visual representation of said first data category if said predefined event is identified by said processor.

12. The apparatus of Claim 11, wherein said display is configured to produce a fourth visual representation of a fourth data category of the plurality of data categories and said processor is configured to control said display to present said first visual representation of said first data category superimposed over said fourth visual representation of said fourth data category and superimpose said fourth visual representation of said fourth data category over said first visual representation of said first data category if said predefined event is identified by said processor.

13. The apparatus of Claim 10, wherein said plurality of data categories are vehicle data categories.

14. The apparatus of Claim 10, wherein said plurality of data categories are aircraft data categories.

22. The apparatus of Claim 18, wherein said second color difference is less than about one hundred (100).

23. The apparatus of Claim 18, wherein said plurality of data categories are vehicle data categories.

24. The apparatus of Claim 18, wherein said plurality of data categories are aircraft data categories.

25. The apparatus of Claim 18, wherein said display is a Multi-Function Display (MFD).

26. The apparatus of Claim 18, wherein said first data category is sensor data.

27. The apparatus of Claim 18, wherein said second data category is navigation data.

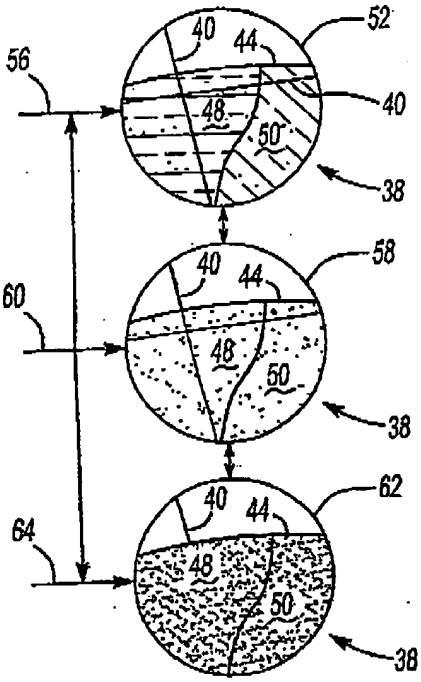
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Fig-3

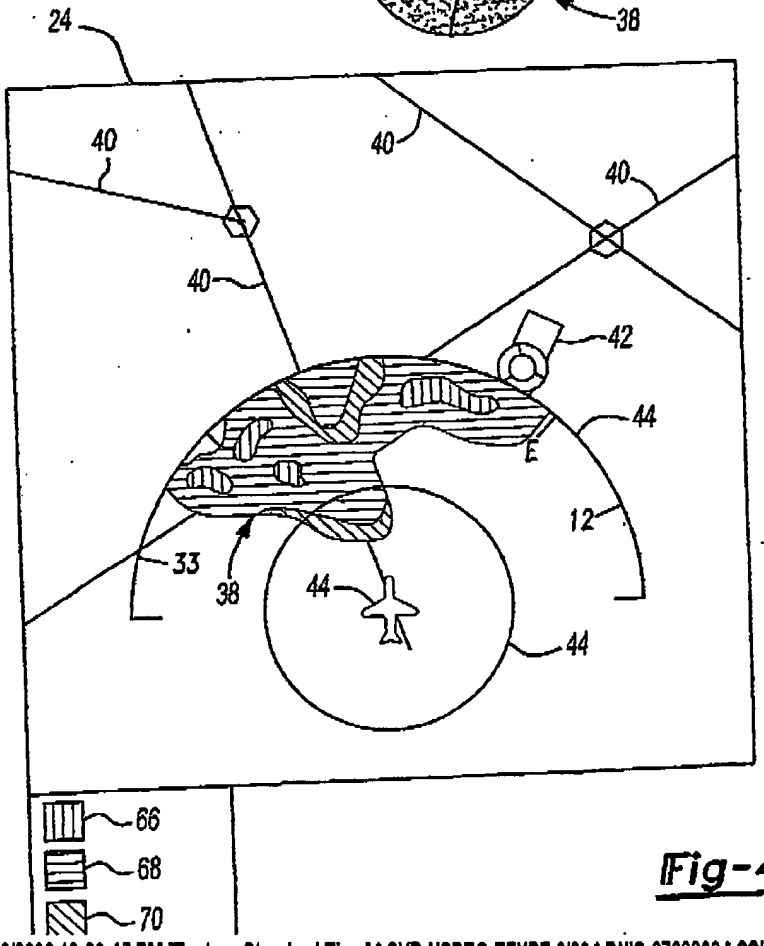
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Fig-4

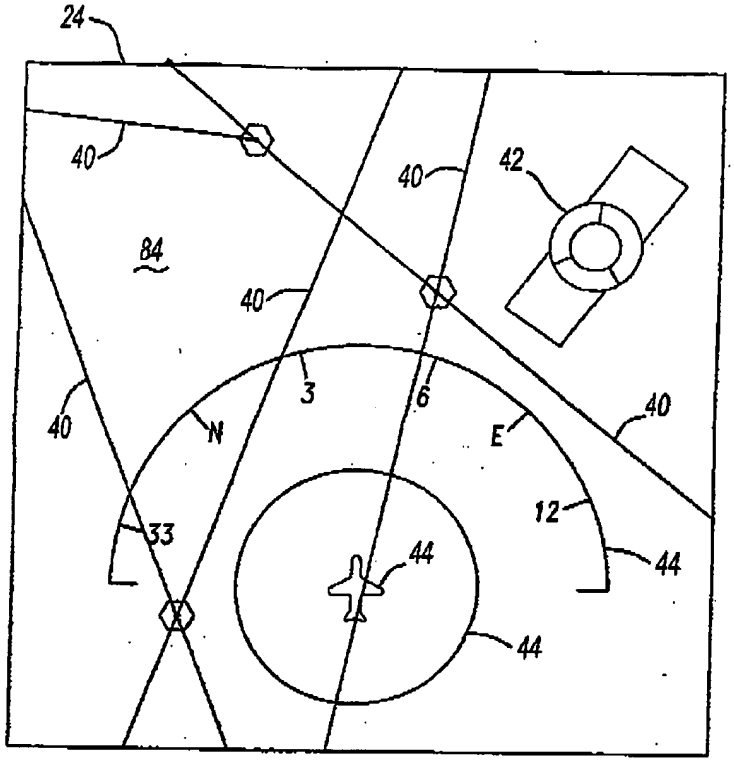
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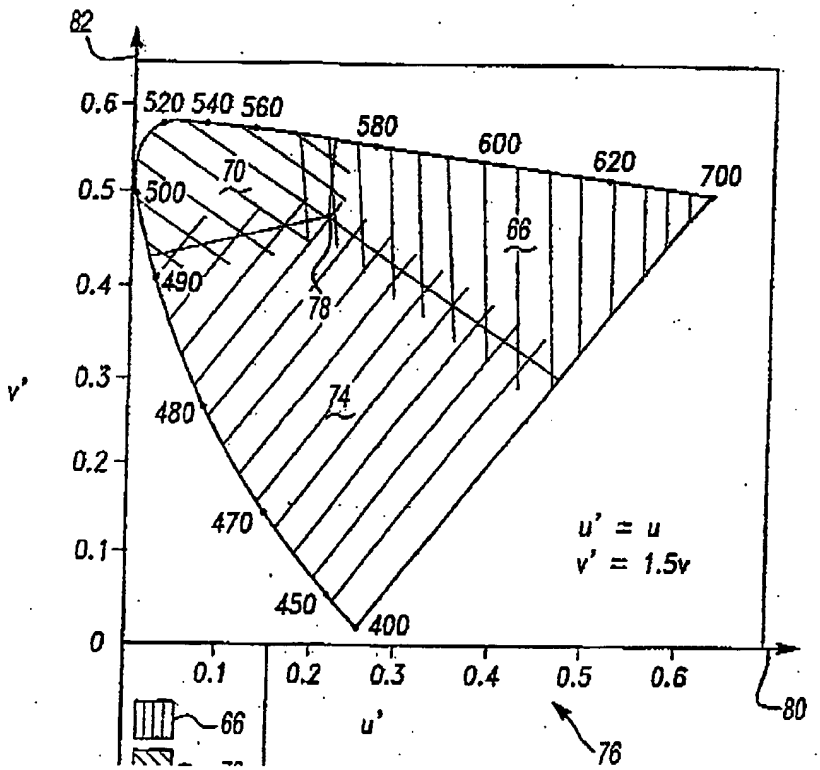
Fig-6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520 540 560
580
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620
700
0.5
500
70
66
0.4
490
78
v'
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74
480
0.2
470
0.1
450
400
0
u' = u
v' = 1.5v
0.1
0.2
0.3
0.4
0.5
0.6
80
66
u'
76

Fig-7

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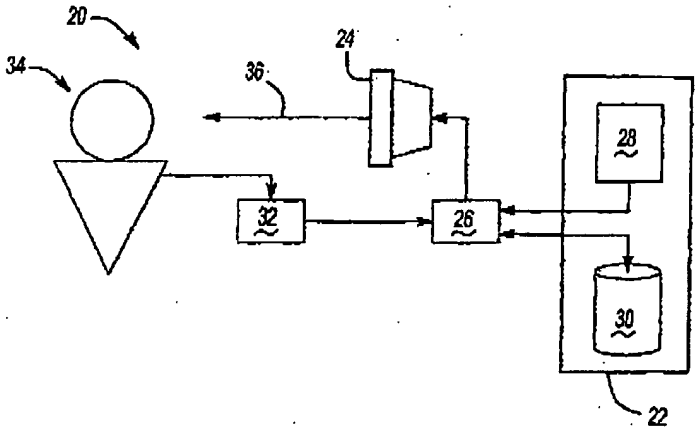

(57) Abstract: Methods and apparatus (20) are provided for displaying multiple data categories (22). The apparatus (20) is comprised of a display (24) that is configured to produce visual representations of the plurality of data categories (22) and a processor (26) that is configured to control the display (24) such that at least one of three display modes is provided for the visual representations of the plurality of data categories (22). The first display mode provided by the apparatus (20) and method is a transparency mode for at least one of the visual representations of one of the data categories (22) and the second display mode provided by the apparatus (20) and method is a dynamic layering mode for the visual representations of the plurality of data categories (22). The third display mode is a color prioritization mode for at least three of the visual representations of three of the data categories (22). One or more

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 02/10809

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.

INTERNATIONAL SEARCH REPORT

Internatio pplication No
PCT/US 02/10809

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WEINDORF P: "THE C-17 MULTIFUNCTION DISPLAY A BUILDING BLOCK FOR AVIONIC SYSTEMS" PROCEEDINGS OF THE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE. (NAECON). DAYTON, MAY 18 - 22, 1992, NEW YORK, IEEE, US, vol. 2 CONF. 44, 18 May 1992 (1992-05-18), pages 836-842, XP000339662 ISBN: 0-7803-0652-X the whole document	7,15,25
X	EP 0 349 458 A (IBM) 3 January 1990 (1990-01-03) abstract; claims; figures	10-12
X	US 6 018 341 A (ROBERTS DAVID JOHN ET AL) 25 January 2000 (2000-01-25) column 4, line 25 - line 43 column 5, line 13 - line 16; figures 6,7	10-12
Y	US 5 883 586 A (TRAN MY ET AL) 16 March 1999 (1999-03-16) column 5, line 52 - line 56 column 14, line 65 -column 15, line 12	10-17
Y	US 5 479 497 A (KOVARIK KARLA) 26 December 1995 (1995-12-26) column 2, line 37 -column 3, line 7	10-17
X	TAM R C ET AL: "Volume rendering of abdominal aortic aneurysms" PROCEEDINGS VISUALIZATION '97. PHOENIX, AZ, OCT. 19 - 24, 1997, ANNUAL IEEE CONFERENCE ON VISUALIZATION, LOS ALAMITOS, CA: IEEE COMPUTER SOC, US, vol. CONF. 8, 19 October 1997 (1997-10-19), pages 43-50,528, XP010270109 ISBN: 0-8186-8262-0 page 47, left-hand column, paragraph 2 - last paragraph	18-22
A	US 6 169 516 B1 (HIROSE SATORU ET AL) 2 January 2001 (2001-01-02) column 28, line 34 -column 32, line 13	18-23,27
A	US 5 884 223 A (TOGNAZZINI BRUCE) 16 March 1999 (1999-03-16) column 3, line 45 - line 51 column 7, line 43 -column 8, line 11	18-27